

## FORMAL FEATURES AS A DESIGN FACTOR OF VIDEO SEGMENTS IN INTERACTIVE VIDEO PROGRAMMES

PLØN. W. VERHAGEN

Department of Educational Instrumentation, Faculty of Educational Science and Technology,  
University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands

**Abstract**—Video segments may be characterized by formal design features with respect to factors such as complexity of narration, mutual influence of picture and sound, use of superimposed texts, information load due to technical terms, and animation. The paper suggests ways to operationalize these factors and reports about an experiment in which the influence of these formal features was studied with respect to perceived information load of video segments by learners. The length of a segment was thereby counted as the number of information elements it contains. An information element is defined as one uninterrupted statement of the narrator about which one factual question can be presented. The experiment was carried out by using an experimental videodisc programme about cheesemaking that contains 252 information elements which form a connected discourse of 36 min if the programme is played linearly without stopping. Subjects had the task to divide this programme into segments by deciding for themselves how often they would stop before completing the programme. At every stopping place, the subjects were questioned about the content of the just completed segment.

The results of the experiment suggest that: (a) subjects tend to perceive narrated sentences as one whole, regardless of the number of facts implied, (b) content-related technical terms seem not to determine difficulty level, (c) superimposed texts show a trend to help subjects who prefer short segments to choose longer segments and subjects who prefer long segments to choose shorter segments, (d) animation is positively (but moderately) correlated with mean self-chosen segment length.

### INTRODUCTION

Interactive video may be conceived as the combination of the interactive capabilities of the computer and the audiovisual power of video. This combination is generally considered as a powerful medium for delivering instruction, nowadays often incorporated in so-called multimedia systems.

An essential property of adding computer control to video programmes is the possibility to stop for questions or exercises or to give feedback to students about their progression, at any desired moment. A simple but fundamental question is: What is the optimum moment to stop for the purpose of achieving maximum learning? The literature gives some ideas with respect to this question, e.g. [1–3]. Very short segments may limit the impact of typical video design factors on the building of discourse to such an extent that the communication possibilities of video are not used to their full potential. On the other hand, very long segments may offer more information than learners can handle. A central issue in this respect is the information load of segments as perceived by the learners. This information load is determined by the number of subject-matter components within each segment and possibly influenced by aspects of the presentation form such as the correspondence of narration and images and the use of superimposed texts. To study the influence of these and similar aspects, an experimental videodisc programme about cheesemaking was used that contains 252 information elements which form a connected discourse of 36 min if the programme is played linearly without stopping [4].

### RESEARCH QUESTION

The study was undertaken to answer the following research question:

To what extent do selected formal features of video segments influence the information load of these segments as perceived by the learners?

An information element is defined as one uninterrupted statement of the narrator about which one factual question can be presented. The subjects who watched the programme had to decide for themselves how often they interrupted the programme, thus determining their preferred segment

lengths. It was hoped that preferred segment lengths would yield insight in the influence of information load on segment length.

Five kinds of formal features, that may influence the information load of the different information elements, were identified and were included in the study:

- number of technical terms per element, *TT*;
- number of meaningful propositions per element, *PP*;
- correspondence of narration and images, *BCC*;
- presence or absence of narration supporting text on screen, *TX*; and
- kind of video image: live or animation, *AN*.

### *Technical terms*

The difficulty of an instructional programme is, in part, determined by the novelty of terms in the programme text. Two factors are at stake:

- (a) novelty of terms as such (new terms are more difficult than familiar ones);
- (b) the number of times that a new word is encountered—each time a new word is encountered, it becomes more familiar, which may decrease its perceived difficulty.

How familiarity of new terms and increase of this familiarity during a lesson have to be taken into account is as yet unclear. Direct measurement of word familiarity appears to be extremely difficult if not impossible, among other things due to subjectivity and cumbersomeness of the methods that may be used [5, pp.48–51]. For the study, it was therefore decided to select a rather straightforward measure to get at least some indications about the influence of novelty of terms on decisions about segment length. *TT* was introduced as a variable in the study to investigate whether novelty of terms requires a weighting factor. In the study, technical terms are rated as new if the terms can be considered unfamiliar to the subjects before they start watching the experimental video programme. A rather simple variable was chosen because it can be rated easily, which is of practical value to media designers. (This consideration is relevant for all the variables.)

A separate study was carried out using a panel of eight experts to categorize technical terms and provide a value of *TT* for every information element.

### *Number of propositions*

Although an information element is defined as one uninterrupted statement of the narrator about which one factual question can be presented, in practice many sentences contain more than one fact that can be logically derived in the form of propositions. The sentence “Pasteurization kills harmful bacteria”, for instance contains two propositions that may both be instructionally relevant: (a) “pasteurization kills bacteria” and (b) “these bacteria are harmful”. *PP* was also used as a measure of complexity of sentences. A feasible rule of thumb is to count such propositions to determine how many facts in an information element lend themselves to question formulation.

The kind of propositions that are sought are thus the “meaningful propositions” that were mentioned by Gagné [15, p.162] as basic building blocks of verbal information acquisition. This approach introduced arbitrary decisions in the process of analysing content. This problem was addressed by asking experts to rate each information element for the number of propositions contained in it (the same panel of experts that was mentioned with respect to rating technical terms).

### *Correspondence of video images and audio narration*

In audiovisual presentations, the visual channel and the audio channel are used simultaneously to convey messages. The literature [6–11] supports the belief that proper between-channel correspondence promotes learning and that *BCC* affects the information load of audiovisual presentations. How to control *BCC* is, however, a complex matter. Factors involved are: (a) the concreteness of subject matter; (b) enrichment versus overload; (c) avoidance of distracting information; (d) amount of cueing of auditory elements by optical markers or changes of shots;

and (e) the mutual tuning of audio and pictures in general, inclusive of the wording and timing of commentary relative to the pictures. For every new product, the designers have to make content-driven local decisions to optimize *BCC* with respect to these factors. This is true for the experimental video programme for the present study as well. For the study, the question is whether *BCC* affects segment length when subjects are free to choose segment length on their own.

### *Correspondence of narration and images*

In this study, the correspondence of video images and audio narration was rated on a four-point scale from 0 to 3 representing the following:

- 0— The narration describes what the video image shows. The content of the narration is visible on the screen. Example: the picture shows a machine shop with a number of cheesemaking tanks. Three are visible. The narration says that “In the machine shop a number of cheesemaking tanks are mounted”.
- 1— The narration presents non-visible factual information that is directly related to the visible objects of the video image. Example: the picture shows the exterior of a curd-dosing machine while the narration says that “within the curd-dosing machine, whey is extracted from the curd as much as possible”.
- 2— The narration presents information that is associated with the video image without being directly related to the depicted objects. Example: the picture shows a general laboratory scene with respect to testing of milk while the narration says that “On entering the cheese plant, the precise composition of the milk is determined”.
- 3— The narration presents information that has no direct association with the video image—the video image is just a background without reinforcing nor affecting the narrated message. Example: the picture shows the same laboratory scene where a laboratory worker is filling a test-tube while the narration says that “milk that does not meet the requirements is elsewhere used for non-food products”.

The same panel rated *TT*, *PP*, and *BCC*.

### *Superimposed text*

A particular form of between-channel correspondence is formed by superimposed texts that support narration. Research by Heuvelman[12] and by Van der Heijden[13] give reason to expect that superimposed texts that support narration may be beneficial for learning. In the current study, *TX* was therefore taken as one of the variables that are hypothesized to play a role with respect to information load of information elements.

The presence or absence of superimposed text is a rather straightforward measure. The answer can only be “yes” or “no”, in the study scored as 1 or 0.

### *Animation*

Animation is traditionally a representation technique from the film and video world. It varies from simple stop-motion formats in which message components are stepwise developed (in instructional situations usually synchronous to narration) to detailed cartoons in full motion. Computers allow the possibility of integrating animation into computer-based instruction.

Rieber[14] posits that in computer-based instruction animation has been used to fulfill or assist one of three functions: attention-gaining, presentation, and practice. Research with respect to the applications of animation for these functions is, however, limited. Rieber sees reason to advise that animation should be incorporated only when its attributes are congruent to the learning task. These attributes include: visualization, motion, and trajectory (the path of travel of an animated object).

In the audiovisual world, the situation is not much better as far as research is concerned. The usefulness of animation techniques seems, however, to be accepted as self-evident. Animation is considered to be a common presentation option that can be put into operation whenever its application seems feasible. However, experience suggests that an important feature of animation is that animated visualizations must be strictly to the point, without any distracting detail[11].

One sequence of the experimental video programme in the present study animated to explain a microscopic phenomenon that cannot be observed through ordinary microscopes. The sequence

fulfills a presentation function. An attempt was made to develop that sequence as a tight combination of images and narration. The specific character of animation, in the context of the programme, led to the decision to regard the presence or absence of animation as a formal feature of the information elements. *AN* was therefore introduced as a variable in the study.

The presence of a video image from a live camera or animation was measured by yes or no, in the study scored as 1 or 0.

## RESEARCH METHOD

### *The experimental interactive video programme*

The experimental videodisc programme had two parts: an introduction of 4.5 min (Information Elements 1–33, 31 questions) that was used to familiarize the subjects with the experimental procedure, and a main programme of 31.5 min (Information Elements 34–252, 219 elements with 213 accompanying questions) which was used as the test section of the experiment. The controller ensures that the video can only be started or stopped between two information elements. This ensures video segments always consist of whole numbers of information elements.

### *Experimental procedure*

The subjects worked individually according to the following basic procedure:

- In the ready position to begin a new segment, the screen showed a video still with the superimposed message “click the mouse”. This video still was the first frame of the information element with which the segment would start.
- After clicking, the programme started playing until the subject decided that it was time to ask for it to stop by again clicking a mouse button. The programme then stopped at the end of the information element in which the stop was requested. This defines a segment: if the playing started with element  $i$ , and the programme stopped at the end of element  $i + k$ , a segment containing  $k + 1$  information elements was created.
- The subject then answered all  $k + 1$  questions about the segment just viewed, one question after the other. All questions were open questions that required short sentences, single words, or numbers to be typed in as answers.
- Next, all questions were repeated one by one corresponding to the order of information elements in the segment together with the answers and feedback. Right answers were reinforced by a complete sentence that restated the correct answer. If a question was answered wrongly, the feedback informed the subject of this fact followed by the message “click the mouse to repeat the related video fragment”. After clicking, this video fragment was repeated followed by a second attempt to answer the question. After this, a second feedback about right or wrong was provided, this time together with the right answer regardless of whether or not the second answer was right or wrong.
- After all questions of the segment were reviewed, the subject was allowed to continue the programme beginning with element  $i + k + 1$ , the information element that followed the last element of the completed segment.

In this way, the subject divided the video programme into segments by the repetition of watching, stopping, answering questions, getting feedback, with built-in repetition of video parts with respect to missed questions, and starting the next segment.

### *Subjects, conditions, and variables*

Subjects were 117 university freshmen of several faculties of the University of Twente in The Netherlands. They worked in one of two experimental conditions: 68 subjects worked in the so-called variable condition (VAR) in which the main programme was presented in its usual order; and 49 subjects worked in the crossed condition (CROSSED) in which the two halves of the main programme were interchanged. This last condition was introduced to study order effects.

It was assumed that the information load as perceived by the subjects will determine the length of the video segments they select: longer segments for easy parts and shorter segments for more

difficult parts of the video programme. The dependent variable used in the study is therefore the length of self-chosen segments, counted as the number of information elements in each segment. The independent variables are the ratings of the formal features and the experimental conditions.

## RESULTS

### *Mean self-chosen segment lengths*

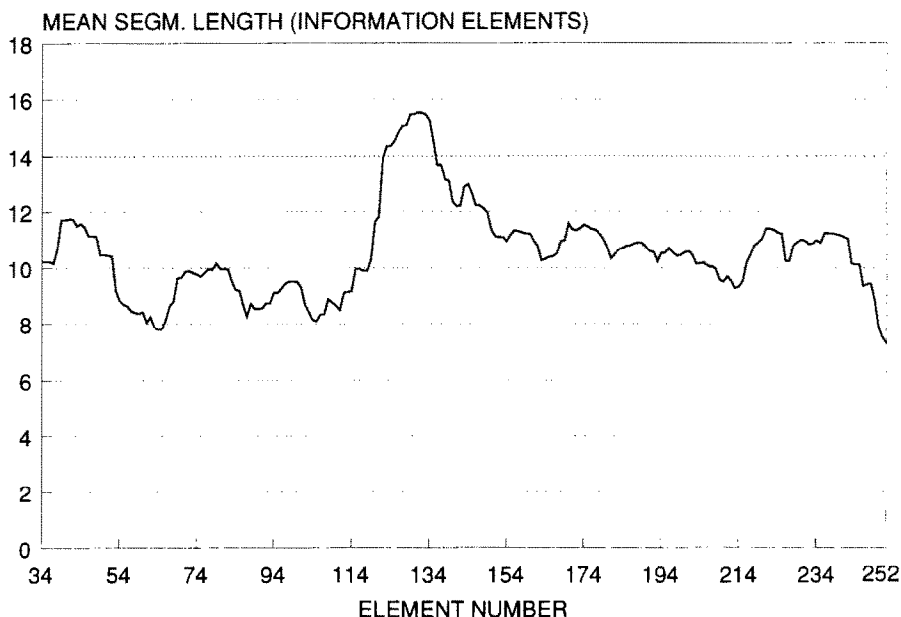
The results of the experiments showed self-chosen segment lengths of which the means per subject varied from 2.19 to 87.50, with a mean of mean length of 12.70 ( $SD = 11.77$ ; VAR and CROSSED conditions pooled).

It is reported elsewhere that no evidence of order effects could be found[4]. Differences between the VAR and CROSSED conditions that would indicate such effects could not be observed.

### *Segment length as a function of the position in the programme*

Figure 1 shows the mean self-chosen segment length as a function of the position in the programme. Each information element was part of one segment per subject. This means that every information element was part of as many segments as there were subjects. In Fig. 1, the values of mean self-chosen segment length for each element number were computed by element as the mean length of all segments of which an element was a part. To be able to observe trends, for instance with respect to gradually shortening or lengthening of self-chosen segment length while working with the programme, a sufficient number of segments per subject are needed. For that reason it was decided to use only the data of subjects with 12 segments or more, and only data of subjects in the VAR condition (who worked in the normal order of the programme).

Figure 1 shows that mean segment length appeared to vary as a function of the position in the programme: subjects as a group appeared to prefer shorter segments at one place in the programme than at other places. It could be that some parts of the programme are perceived as being easier than other parts. If all information elements were of equal information load, the line in Fig. 1 would be much more horizontal. That this did not happen may be caused by formal features of the information elements. This led to the following analyses.



Only data from VAR subjects with 12 segments or more ( $N=57$ ).

Fig. 1. Mean self-chosen segment length by element number.

Table 1. Correlations of formal features within information elements

	<i>TT</i>	<i>PP</i>	<i>TX</i>	<i>AN</i>	<i>BCC</i>
<i>TT</i>	1.000				
<i>PP</i>	0.0702	1.0000			
<i>TX</i>	-0.0457	-0.0676	1.0000		
<i>AN</i>	-0.1198	-0.0723	-0.2051*	1.0000	
<i>BCC</i>	-0.0149	-0.0016	0.2995**	-0.2748**	1.0000

*TT* = number of technical terms; *PP* = number of propositions;  
*TX* = superimposed text; *AN* = animation; *BCC* = between-channel correspondence.  
Number of cases: 219 (= information elements 34-252). 2-tailed significance *P*: \* = 0.01; \*\* = 0.001.

Effects of formal features

Not all formal features are independent. The correlations between the different variables within the information elements of the programme are presented in Table 1.

Table 1 shows that in the experimental video programme, *TT* and *PP* can be considered as independent of each other and of the other variables. The significant correlations in the table are all low. *AN* and *TX* are weakly negatively correlated. This value is difficult to interpret, given the fact that the programme contains only one sequence of 11 information elements presented in the form of animation, while the absence of text in that part is considered to be accidental. The correlation between *AN* and *BCC* has some meaning because *BCC* plays a role throughout. A high score on *BCC* means low between-channel correspondence. The negative correlation with *AN* thus means that more animation means better *BCC*. Similarly, if superimposed texts are used, between-channel correspondence is often low.

The formal features show significant but only very small correlations with mean self-chosen segment length if all segments of all subjects are taken together (Table 2).

A possible reason for the findings is that all features (except *AN*) are rather evenly spread over the programme as a whole. Differences between subjects then tend to disappear by compensatory effects of other subjects. The individual subjects are, nevertheless, in a position to base their behaviour on formal features, especially for subjects with short mean self-chosen segment lengths given that the chain of information elements in the programme showed peaks and dips in density for each formal feature (Verhagen[4]). For each subject with sufficient segments (12 or more) the correlations of segment length and the formal-feature variables were determined. These correlation coefficients are plotted as functions of mean self-chosen segment lengths and the regression lines

Table 2. Correlations of formal features with segment length summarized over all segments of all subjects in the VAR condition with 12 segments or more

	<i>TT</i>	<i>PP</i>	<i>TX</i>	<i>AN</i>	<i>BCC</i>
Self-chosen segment length	-0.0557*	-0.0565*	-0.0055	0.1137**	-0.0919**

*TT* = number of technical terms; *PP* = number of propositions; *TX* = superimposed text;  
*AN* = animation; *BCC* = between-channel correspondence.  
Self-chosen segment lengths pooled from all subjects.  
Number of cases: 1803. 1-tailed significance *P*: \* = 0.01; \*\* = 0.001.

Table 3. Regression of the correlations of formal features and segment length for each subject, as a function of mean self-chosen segment length

	<i>TT</i>	<i>PP</i>	<i>TX</i>	<i>AN</i>	<i>BCC</i>
Correlation	0.32	-0.17	-0.36	0.40	-0.38
Explained variance	0.10	0.03	0.13	0.16	0.14
Standard error	0.20	0.23	0.23	0.21	0.27
Level of significance	0.0161	0.195	0.0053	0.002	0.004
Intercept	-0.213	-0.046	0.114	0.164	-0.025
standard error	0.059	0.067	0.067	0.061	0.079
Slope	0.014	-0.009	-0.019	0.019	-0.023
standard error	0.006	0.007	0.006	0.006	0.008

Only VAR subjects with 12 segments or more.  
*TT* = number of technical terms; *PP* = number of propositions; *TX* = superimposed text; *AN* = animation; *BCC* = between-channel correspondence.

are computed. The results are displayed in Table 3 and Fig. 2. The fact that the regression with respect to *PP* did not reach significance (Table 3) was the reason to limit Fig. 2 to the plots of *TT*, *TX*, *AN*, and *BCC*.

Although the regression lines represent low correlations, the plots show that for some subjects substantial correlations exist. However, what is a positive correlation for one person, can be negative for another.

The direction of the lines for *AN* and *BCC* show that on average more *AN* or more *BCC* (which is a lower *BCC* score) allow longer mean self-chosen segment lengths. The explained variances for these factors are, however, small. For *AN* the amount of explained variance is 16%, for *BCC* 14% (Table 3).

For short mean self-chosen segment lengths, more *TT* leads on the average to shorter segments. The influence is, however, very weak. The explained variance of the regression line is 10%. The density of *TT* is not equal at all places in the programme. This means that there were occasions for a correlation of segment length with *TT* to develop. The limited influence may therefore be interpreted as evidence that the subject matter of the programme was not too difficult, although care has to be taken because of the small effects.

The regression for *TX* shows that, on average, *TX* has hardly any influence on segment length, but for longer segments a small negative influence develops. However, care has to be taken because for longer segments *TX* is rather evenly spread over the programme, even though the explained variance is limited to 13%.

*PP* seems not to influence mean self-chosen segment length in any way (Table 3).

## DISCUSSION

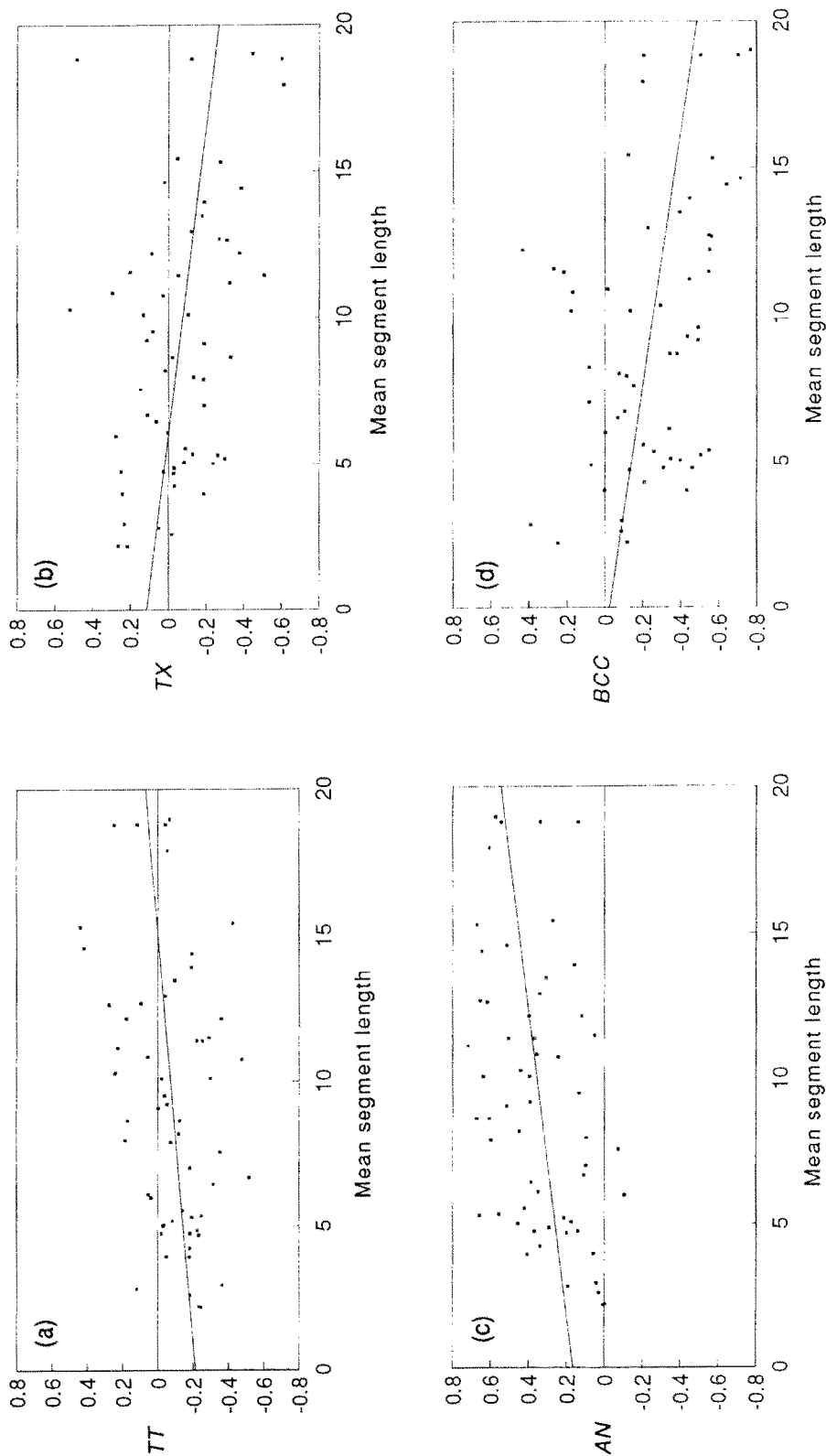
Within the individual information elements, correspondence of narration and images (*BCC*) correlates weakly with the factors "text on screen" (*TX*) and "animation" (*AN*) (Table 3). *TX* is positively correlated with lack of *BCC* ( $R = 0.2995$ ). This agrees with the research of Heuvelman[12], who recommended that abstract information may be supported by superimposed texts. The condition he mentioned, that the quantity of superimposed texts should in that case be chosen with care and should preferably take the form of keywords or key phrases, is fulfilled in the study[4]. *AN* is positively correlated with better *BCC* ( $R = 0.2748$ ). This supports Wember's insight that abstract or difficult information may benefit from animation because of the opportunity to visualize the essentials of the message without distracting details[11].

The existence of mean self-chosen segment lengths longer than nine implies that subjects found the time to memorize the information. The lack of correlation between implied facts (*PP*) and mean self-chosen segment length (Table 3) seems thereby to indicate that subjects stored the story as presented, without worrying too much about the kind of questions that they might receive. The present study was, however, not designed to find a detailed answer to this question. New experimental conditions, in which the number of questions as well as the kind of questions (for instance open questions versus multiple-choice questions) would be varied, are recommended to shed light on this matter.

The other formal features (number of technical terms, *TT*; superimposed text, *TX*; animation, *AN*; and between-channel correspondence, *BCC*) show small, in most cases almost negligible correlations with mean self-chosen segment length, as evidenced by the intercepts and slopes of Table 3. The scatter plots and regression lines of Fig. 2 suggest, nevertheless, some interesting considerations.

### *Individual differences*

The scatter plots show that each of the factors was variously important to different subjects. It is interesting that, for instance, *TT* correlated positively with mean self-chosen segment length for some subjects (subjects who liked to follow a discourse with new information without being interrupted too soon), and negatively for others (subjects who found segments difficult if too many technical terms were presented). Similar speculations apply to the other factors. Does superimposed text help some subjects, by the redundancy of its content, to maintain watching, and trigger other students to stop more quickly because the text hinders the discourse? The animation seems for



A larger score for BCC means a lower between channel correspondence.  
Only VAR subjects with 12 segments or more ( $N=57$ ).

Fig. 2. Correlations of selected formal features and mean segment length.



almost all subjects to be positively correlated with mean self-chosen segment length, but large individual differences exist. Between-channel correspondence seems to increase mean self-chosen segment length for the majority of the subjects (for whom *BCC* is negatively correlated with mean self-chosen segment length; a higher *BCC* score means lower correspondence). However, some subjects behaved differently and chose shorter segments if the between-channel correspondence was high. Were they sufficiently bored by the easiness of a presentation with high between-channel correspondence so that they stopped quickly to deal with the associated questions?

These observations confirm the position of Salomon, who stated that there is “a rapidly growing body of empirical evidence to indicate that no media variable, minute or gross as it may be, affects all groups of learners in one and the same way” [16, pp.395–396]. Still, rules for good audiovisual practice are indicated, to develop methods for optimal design decisions in given situations. Group-based trends may be informative in this respect as shown by the regression lines.

### *Technical terms*

The regression line for *TT* shows that the presence of technical terms influenced mean self-chosen segment length. On average, this influence was very small and changed from negative for mean self-chosen segment length shorter than 15 information elements to positive thereafter. This agrees with the earlier speculation that the small influence of *TT* can be regarded as evidence that the subject matter of the programme was not too difficult. More technical terms in longer segments seem not to be a problem, whereby the positive slope may be explained by the fact that subjects who chose longer segments were more proficient in dealing with larger chunks of information.

### *Superimposed text*

The trend with respect to *TX* shows that mean self-chosen segment length shows at first a weakly positive correlation with the amount of superimposed text. The negative slope of the trend line crosses the *X*-axis around a mean self-chosen segment length of about six information elements. This negative relationship may occur if text on screen limits or disturbs the continuity of the video presentation and may be caused by the numbers that appear as superimposed text on the video image. A completed list of numbered elements suggests a place to stop. It is elsewhere reported that the subjects stopped in 9% of the cases at the end of a list, which is about three times as often as would be expected if segments were concluded at random places [4].

### *Animation*

The trend of *AN* was expected to be clear because it was developed in such a way that all distracting details were excluded, to exploit the animation. The positive correlation with mean self-chosen segment length agrees with this assumption. The animation relates, however, to only one sequence of 11 information elements, which makes it necessary to interpret this finding with care.

### *Between-channel correspondence*

As with *AN*, the trend of *BCC* was according to the expectations. Better between-channel correspondence is expected to lead to longer segments, as suggested by the regression line in Fig. 2(d).

The effects that are observed in this study are rather small. Should that not lead to the conclusion that the audiovisual design features seem to be unimportant factors? Such a conclusion is not warranted. The audiovisual design was based on the careful combined application of the formal features studied. This approach limits the possibilities to generate knowledge about isolated formal features, as these factors are exploited in combination throughout the experimental video programme in the way that audiovisual professionals maximize the impact of the instructional messages they develop. In less-optimal material, one or several of the features might have been more important. This is a similar argument of that of Mayer [17], who suggested that one didactical measure—orienting activities—may lose its impact by proper utilization of other instructional variables. It is, in other words, necessary to design further experiments to study the individual features in more detail to obtain information about the importance of the individual factors.

### *Conclusions about formal features*

- (1) The information elements as they were identified within the experimental video programme can be considered as content units. Subjects tend to perceive narrated sentences as one whole, regardless of the number of facts implied.
- (2) The number of technical terms in each segment seems not to be a factor that influenced mean self-chosen segment length to such an extent that the subject matter was perceived as difficult by the subjects.
- (3) Superimposed text shows a trend from a small positive relationship to mean self-chosen segment length (for lengths shorter than about six information elements) and a small negative relationship with mean self-chosen segment length for lengths that are longer. This relationship is, however, weak in this study.
- (4) Animation is positively, but moderately, correlated with mean self-chosen segment length.
- (5) Between-channel correspondence stimulates the selection of longer segments, albeit that the correlation is small.

### REFERENCES

1. Bork A., Lessons from computer-based learning. In *Interactive Media: Working Methods and Practical Applications* (Edited by Laurillard D.), pp. 28-43. Ellis Horwood, Chichester (1987).
2. Laurillard D., Pedagogical design for interactive video. In *Interactive Media: Working Methods and Practical Applications* (Edited by Laurillard D.), pp. 74-90. Ellis Horwood, Chichester (1987).
3. Schaffer L. and Hannafin M. J., The effects of progressively enriched interactivity on learning from interactive video. *Educl Commun. Technol. J.* **34**, 89-96 (1986).
4. Verhagen P. W., Length of segments in interactive video programmes. Unpublished Ph.D. dissertation. Faculty of Educational Science and Technology, Univ. of Twente, Enschede (1992).
5. Van Hauwermeiren P., *Het leesbaarheidsonderzoek (Readability Research)*. Tjeenk Willink, Groningen (1975).
6. Grimes T., Audio-video correspondence and its role in attention and memory. *Educl Technol., Res. Dev.* **38**, 15-25 (1990).
7. Drew D. G. and Grimes T., Audio-visual redundancy and TV news recall. *Commun. Res.* **14**, 452-461 (1987).
8. Colavita F. B., Human sensory dominance. *Perception Psychophys.* **16**, 409-412 (1974).
9. Posner M. I., Nissen M. J. and Klein R. M., Visual dominance: an information-processing account of its origins and significance. *Psychological Rev.* **83**, 157-171 (1976).
10. Kozma R. B., Learning with media. *Rev. Educl Res.* **61**, 179-211 (1991).
11. Wember B., *Wie informiert das Fernsehen? (How Does Television Inform?)*. List, Munich (1976).
12. Heuvelman A., *Buiten beeld (Off Screen)*. Swets & Zeitlinger, Lisse (1989).
13. Van der Heijden M. P., *Tekst en videobeeld. Een onderzoek naar de vormgeving van het videobeeld door teksten en/of live-action videobeelden in informatieve video-voorlichtingsprogramma's* (Text Images and Video Images. An Experiment into the Realization of the Video Image by Texts or by Live-action Images in Informative Video Programmes). Department of Education, Univ. of Twente, Enschede (1987).
14. Rieber L. P., Animation in computer-based instruction. *Educl Technol. Res. Dev.* **38**, 77-86 (1990).
15. Gagné R. M., *The Conditions of Learning and Theory of Instruction*, 4th edn. Holt-Saunders, New York (1985).
16. Salomon G., What is learned and how it is taught: the interaction between media, message, task, and learner. In *Media and symbols: the forms of Expression, Communication, and Education; The Seventy-Third Yearbook of the National Society for the Study of Education* (Edited by Olson D. R.), pp. 383-406. Univ. of Chicago Press, Chicago (1974).
17. Mayer R. E., Aids to text comprehension. *Educl Psychol.* **19**, 30-42 (1984).